NEW HAMPSHIRE DIVISION OF HISTORICAL RESOURCES

State of New Hampshire, Department of Cultural Resources 603-271-3483
19 Pillsbury Street, P. O. Box 2043, Concord NH 03302-2043 603-271-3558
Voice/TTY RELAY ACCESS 1-800-735-2964 FAX 603-271-3433
http://www.state.nh.us/nhdhr *preservation@nhdhr.state.nh.us*

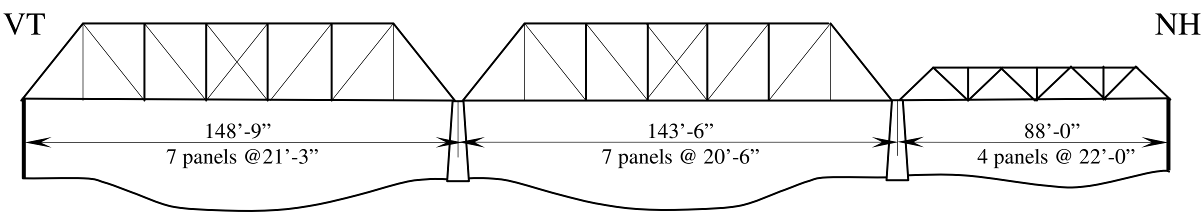
BRIEFING PAPER ON THE CONNECTICUT RIVER BRIDGE (BRIDGE 058/127) ON ROUTE 4 BETWEEN WEST LEBANON, NEW HAMPSHIRE AND WHITE RIVER JUNCTION IN HARTFORD, VERMONT

JAMES L. GARVIN

AUGUST 30, 2008

This report is based on a brief meeting and inspection of the bridge in the morning of August 7, 2008. The meeting involved representatives of the New Hampshire Department of Transportation and the Vermont Agency of Transportation. The purpose of the meeting was to discuss the condition of the bridge, possible strategies for maintaining heavy truck traffic over the Connecticut River at or in the vicinity of the bridge, possible effects on National Register-eligible properties near the bridge, and archaeological concerns that may accompany various choices for project design.

The West Lebanon-Hartford Bridge is a three-span structure with two high Pratt truss spans and, on the New Hampshire end, a shorter low (pony) Warren truss span.



The irregularities of the truss lengths, and other attributes of the geometry of the bridge, reflect the history of previous bridges at this crossing. The first bridge at this site was built in 1805 and linked the Fourth New Hampshire Turnpike with the White River Turnpike. The New Hampshire legislature chartered a new Lyman's Bridge Company to erect a replacement bridge here in 1836, and this corporation built a covered wooden toll bridge. As noted below under "History of this crossing," the covered bridge was supported by rather crude stone piers in approximately the same locations as the piers under the current bridge. The covered bridge was reportedly destroyed by a freshet in 1896 and replaced in 1896-7 by a steel bridge that was supported by new granite piers in approximately the same location as the piers of the earlier covered bridge. The present bridge stands upon the piers that were built in 1896-7.

The present bridge at this crossing was built by the American Bridge Company in 1936. As noted, the current bridge stands on a substructure dating from 1897, although the bridge elevation was raised by the addition of concrete bridge seats atop the stone abutments and piers. The recorded span lengths of the 1936 bridge are 88'-0", 143'-6", and 148'-9".

The current bridge has a width between truss centerlines of 27'-6" with a six-foot cantilevered sidewalk on the downstream (south) side, while the 1897 bridge had a roadway 20 feet wide and one six-foot sidewalk. The added width of the 1936 bridge was accommodated on the old piers by placing steel cantilevers across the tops of each pier to support the more widely separated bridge bearings. This method was often used when new superstructures were placed on older substructures after the floods of 1927 and 1936, allowing the new spans to be erected quickly in instances when older piers has survived the floods and were deemed capable of supporting the new spans but were not wide enough for the new structures.

In keeping with common practice during the 1920s and 1930s, most of the web members of the 1936 bridge trusses are composed of rolled sections (typically, 10" wide-flange members), rather than built-up sections.

By contrast, both the heavier truss members such as the end posts and top chords, and the lighter members such as upper lateral bracing, are built up of channels, angles, and lacing bars as seen in the photograph below. All original connections in the bridge are riveted.

History of this crossing: Various accounts of the history of this crossing make some unsupported statements that confuse the origins of three bridges that preceded the current span. The chronology given below attempts to provide documentation for each statement regarding the history of the various bridges.

This bridge long bore the name of "Lyman's Bridge." It was stated as early as 1881 in the *Independent Statesman*, published in Concord, N. H., that the first Lyman's Bridge "was built under a charter from the New Hampshire Legislature, in 1803, granting to a Mr. Lyman the right to build the only bridge across the Connecticut River between Plainfield and Hanover [N. H.]."[1] No documentation of this purported charter can be found. Among the charters granted by the New Hampshire legislature in 1803, however, was that of the "Proprietors of Lyman Bridge."[2] This act permitted a bridge to be erected across the Connecticut River between Lyman, New Hampshire (which then extended to the banks of the river) and Barnet, Vermont, far to the north of Lebanon. It appears that the name "Lyman Bridge" has been confused with that of "Lyman's Bridge."

In fact, the acts of the New Hampshire legislature that ultimately led to the building of Lyman's Bridge took place in 1792 and 1794. On June 20, 1792, the legislature chartered a corporation

[1] *Independent Statesman* (Concord, N. H.), September 22, 1881, p. 405, Issue 51, Col. A.
[2] *Laws of New Hampshire*, Vol. 7, Second Constitutional Period, 1801-1811 (Concord, N. H.: Evans Printing Co., 1918), "An Act to Authorise [*sic*] Calvin Palmer and His Associates to Erect and Keep in Repair a Bridge Across Connecticut River," December 24, 1803, pp. 199-201.

that had ambitious plans not only to bridge the river but also to make the White River Falls, which extend from Lebanon north to Hanover on the Connecticut River, more safely passable by river boats. The charter incorporated Ebenezer Brewster, Aaron Hutchinson, and Rufus Graves, together with others who would join them, as "The Proprietors of White-river-falls-bridge." The proprietors were empowered

> to cut canals, and lock all the falls in Connecticut river between the mouth of Mink brook in said Hanover, and the eddy below the lower [rock] bar of white river falls in Lebanon, and likewise [granted] the privilege of building a bridge over said river in any place within the limits aforesaid, not to interfere with private property, or the grant of any ferry without compensation to the owner.[3]

Brewster, Graves, and Hutchinson eventually discovered that their charter of 1792 did not protect the monopoly that they felt was necessary to carry out their plans. Petitioning the legislature, the associates noted that "they have not [been granted] the exclusive right and privilege vested in them their heirs and assigns of erecting and maintaining said bridge, cutting said canals and locking said falls within the aforesaid limits," and that they had not been "empowered to appropriate the lands of private persons (as in the case of highways) for carrying into effect the purposes aforesaid." They therefore petitioned for an amendment to their charter.

On January 21, 1794, the New Hampshire legislature passed "An Act in addition to and [in] amendment of an act entitled 'an act to incorporate certain persons for locking falls, cutting canals and building a bridge over Connecticut river.'" The new law granted the proprietors a mechanism to lay out roads or towpaths over private property by application to appropriate boards of selectmen, and extended the limits within which they might locate their proposed bridge. The new law provided

> That the proprietors aforesaid their associates, heirs and assigns, be and they hereby are invested with the exclusive right and privilege of erecting said bridge over Connecticut river aforesaid, any where between the mouth of said white-river and two miles north of Mink-brook [provided that] in building & completing said bridge, [they] shall not interfere with the grant of a ferry heretofore made to the Trustees of Dartmouth College, within the limits aforesaid.[4]

Charles A. Downs' *History of Lebanon, New Hampshire* makes it clear that the first White River Falls Bridge company was also chartered in Vermont. Downs says,

> October 21, 1795, the Vermont Legislature passed an act incorporating Ebenezer Brewster, Rufus Graves of Hanover and Aaron Hutchinson, Esq., with those who

---

[3] *Laws of New Hampshire*, Vol. 6, Second Constitutional Period, 1792-1801 (Concord, N. H.: Evans Printing Co., 1917), "An Act to incorporate certain persons for locking falls, cutting canals, and building a Bridge over Connecticut river," June 20, 1792, pp. 18-20.

[4] Ibid., "An Act in addition to and amendment of an act entitled "an act to incorporate certain persons for locking falls, cutting canals and building a bridge over Connecticut river," January 21, 1794, pp. 133-134.

> should become proprietors with them, a corporation under the name of The Proprietors of the White River Falls Bridge, by which act they were invested with the exclusive privilege of building a bridge or bridges over the Connecticut River anywhere between the mouth of White River and the lower part of White River Falls on the Connecticut River.[5]

The more constrained geographical limits of the Vermont charter suggest that the proprietors had narrowed the practicable scope of their project by 1795 to approximately the location of the current bridge.[6]

Downs proceeds to show how the Proprietors of the White River Falls Bridge divested themselves of their privilege and how the first bridge, as built, received the name of Lyman's Bridge:

> The above-named persons conveyed all their interest in this corporation to Elias Lyman of Hartford, Vt. Brewster [conveyed his interest on] January 21, 1801, Graves [conveyed his interest on the] same date, Hutchinson [conveyed his interest on] January 29, 1803, to Elias and Justin Lyman, who had then become associated in business.
>
> A bridge was built over the Connecticut by the Lymans on the site of the one now [1908] known as Lyman's bridge, about the year 1802 or 1803. No reference whatever is found on the [Lebanon] town records relative to this bridge.[7]

The *Political Observer* of Walpole, News Hampshire, reported on February 9, 1805, that

> Mr. Elias Lyman of Hartford has erected a bridge across the Connecticut between Lebanon, N. H. and Hartford, Vt. It connects the White River Turnpike with the Fourth New Hampshire Turnpike. Great advantages are promised from this bridge. Its construction is said to be excellent.[8]

Dissatisfaction over the tolls that were charged at this important crossing arose as early as the 1820s. In February, 1826, the following petition of two years earlier was printed in the *New-Hampshire Patriot and State Gazette*, published in Concord, N. H.:

---

[5] Rev. Charles A. Downs, *History of Lebanon, N. H., 1761-1887* (Concord, N. H.: Rumford Printing Company, 1908), p. 203.

[6] For a detailed history of the Proprietors of the White River Falls Bridge and their efforts to lock the White River Falls and build a bridge across the Connecticut River upstream at Hanover, see W. R. Waterman, "The Story of a Bridge," *Historical New Hampshire* 20, 1 (Spring 1965): 3-26, and W. R. Waterman, "Locks and Canals at the White River Falls," *Historical New Hampshire* 22, 3 (Autumn 1967): 22-54.

[7] Downs, p. 204. A date of 1802 was assigned to the "Lyman bridge, so called" in the *Report of the Bridge Commissioners of the State of New Hampshire to the Legislature, Dec, 31, 1906* (Manchester, N. H.: John B. Clarke Company, 1906), pp. 4-5.

[8] Quoted in Lyman S. Hayes, *The Connecticut River Valley in Southern Vermont and New Hampshire* (Rutland, Vt.: The Tuttle Company, 1929), p. 160.

To the Honorable Senate and House of Representatives of the State of New-Hampshire in General Court convened.

The undersigned petitioners, inhabitants of the town of Lebanon, respectfully represent, that the bridge across Connecticut river, known by the name of Lyman's bridge, is situated in this town. That the proprietors of said bridge are not, at present, as they believe, authorized by any existing charter, to demand or receive toll of travelers for crossing the same: That the amount of toll is not regulated or limited by any act of the legislature, but depends wholly upon the will of the proprietors: That the original expense of building said bridge did not exceed eight thousand dollars, and that the toll at its present rate, if any fixed rate can be said to exist, amounts annually to not less that fifteen hundred dollars.

It has, therefore, in the opinion of the subscribers, become necessary for the public good, in order to guard against unreasonable exactions in future, that the legislature should interfere and establish a reasonable and uniform rate of toll, and they pray that the same may be established accordingly.

Signed by

Calvin Benton, and others.

Lebanon, Dec. 6, 1824.

STATE OF NEW-HAMPSHIRE.

In the House of Representatives, June, 19, 1825.

Ordered, that the further consideration of the petition of Calvin Benton and others for regulating tolls on Lyman's Bridge, be postponed until the second Tuesday of the next Session: That the petitioners and all persons interested, be then heard before the standing Committee on Roads, Bridges and Canals. That the petitioners cause personal notice to be given to the proprietors of Lyman's Bridge, and notice to all others interested, by publishing the substance of said petition and this order, three weeks successively in the New-Hampshire Patriot, the last publication to be at least three weeks prior to said day of hearing.

Attest, M. L. NEAL, Clerk

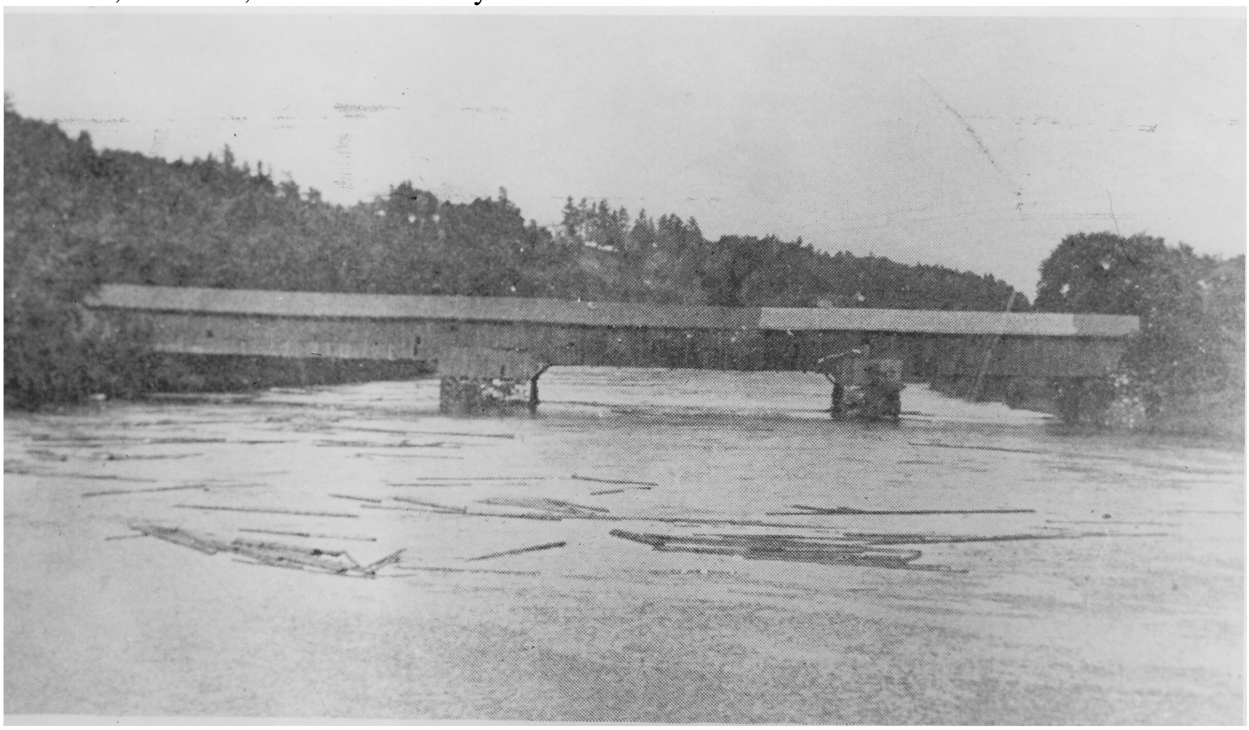
Copy examined by

P. CHADWICK, Assistant Clerk

The outcome of this hearing is unknown, but the original corporation was eventually dissolved and replaced by another.

A new Lyman's Bridge Corporation was created by charter in 1836. According to Downs' *History of Lebanon*, the new corporation was authorized to erect a toll bridge across the Connecticut River between Lebanon and Hartford at any place between the lower rock bar of White River Falls and the southerly boundary of the Town of Lebanon. The bridge that the newly-chartered Lyman's Bridge Corporation erected in 1836 was a covered bridge; its 1805 predecessor had presumably been an open stringer bridge. The covered bridge survived until it was "washed away" in 1896, and is pictured in the book *50 Old Bridges of Lebanon, New*

Hampshire.[9] A photograph (reproduced below) is also to be found in the collections of the Hartford, Vermont, Historical Society.



Lyman's Covered Bridge with the Connecticut River at flood stage.
Courtesy of the Hartford, Vermont, Historical Society

As noted earlier, the 1836 bridge had stone piers in locations that appear to match those of the current substructure, but these earlier piers were built of native rubble, not ashlar, and the piers were relatively low, leaving the wooden superstructure to be supported well above the top of the stonework by wooden cribs or struts. It is difficult to tell from available photographs how far the covered bridge was elevated above the river, but the bridge appears to have been somewhat lower than its successor of 1897, and much lower than the existing 1936 bridge.

As had been the case in the 1820s, the presence of a toll bridge at this crossing eventually became a serious source of aggravation to the towns of Lebanon and Hartford. In 1866, Asa T. Barron, a well-known hotelier, and Oscar Barron had purchased all the stock of the bridge corporation, thus becoming sole owners of the toll bridge.[10] The various steps that were taken to "free" the bridge, beginning around 1875, are related in some detail in Downs' *History of Lebanon*, and were also reported, with some misunderstandings or distortions, in newspapers of the 1870s and early 1880s. Apart from issues concerning the laying out of a public highway across the bridge and assessing the resulting damages to be awarded to the Barrons, the

---

[9] *Report of the Bridge Commissioners of the State of New Hampshire to the Legislature, Dec. 31, 1906* (Manchester, N. H.: John B. Clarke Company, 1906), pp. 14-15; Robert H. Leavitt and Bernard F. Chapman, *50 Old Bridges of Lebanon, New Hampshire* (Lebanon: Lebanon Historical Society, 1975), p. 24.
[10] Downs, *History of Lebanon, N. H.,* pp. 305-311.

procedure involved a legal determination of the exact location of the boundary between New Hampshire and Vermont, or specifically between Lebanon and Hartford. Downs reports that the total cost of "freeing" Lyman's Bridge was ultimately about $7,404.

The new bridge of 1897 was built by the Berlin Iron Bridge Company. *Berlin Bridges and Buildings* (Vol. I, No. 7, October 1898) describes a bridge in Lebanon as a "Pratt Truss Bridge consisting of three spans, two 141 ft. long and one 83 ft. long with a roadway 20 ft. wide and one 6 ft. [side]walk." As noted above, the piers and abutments of the covered bridge were relatively crude in construction. They were replaced by a new stone substructure in 1896; this substructure, extended by concrete bridge seats that elevate the current bridge, remains in service.

Piers for the Third Lyman's Bridge under construction in 1896, using part of the covered bridge as support for a derrick, with the temporary bridge downstream.
Courtesy of the Hartford, Vermont, Historical Society

The cost of building the Berlin Iron Bridge Company span was shared by the towns of Lebanon, New Hampshire, and Hartford, Vermont, with the latter paying only a small percentage of the cost since the boundary between the two towns (and states) is the western shore of the Connecticut River. The Lebanon town reports for the years ending in February of 1896 and 1897 document the expenditures of that town; similar reports for Hartford are not presently available.

The total cost of the new bridge to the two communities was reported to be $40,766.04, with Lebanon paying $32,287.54 and Hartford paying $8,478.50.[11]

The Lebanon town reports document that town's share of the expenses of constructing the new bridge.[12] The Berlin Iron Bridge Company placed a temporary bridge across the river at a cost to Lebanon of $1,300. The granite abutments and piers were built at a cost of $8,032.16 by the Berlin Iron Bridge Company, with "extra work" (perhaps the provision of the quarried stone) by the George E. Lyons Granite Company at an additional cost of $3,299.96. The substructure must have been placed on deep and substantial footings; the bridge accounts list payments to three men for "use of engine[s] and pump[s]," and George W. Townsend was employed as a diver.

The Berlin Iron Bridge Company received payments of $7,750.00 in 1896 and $10,008.05 in 1897 for the superstructure.

Although the Berlin Iron Bridge Company was known for providing bridges of its own design and fabrication, the Town of Lebanon employed its own engineer and inspector for this important structure. The town employed Robert Fletcher as consulting engineer, paying him $232.10 in 1896 and $60.52 in 1897. The town also employed Fred R. French as inspector, paying him $193.25 in 1896 and $17.25 in 1897.

An eminent engineer, Robert Fletcher was born in New York City in 1847, but his parents were both from Vermont. He graduated from the U. S. Military Academy at West Point in 1868, and was immediately hired to teach mathematics at West Point at the age of twenty-one. Sylvanus Thayer, who reformed the Military Academy at West Point and brought it up to the standard of the best military schools in the world, endowed the Thayer School of Civil Engineering at Dartmouth with a gift of $70,000. Thayer is said to have hand-picked Robert Fletcher to direct the Thayer School in 1871 when Fletcher was only twenty-four. Fletcher served on the Dartmouth faculty for forty-seven years, retiring in 1918.

Fletcher and fellow engineer Jonathan Parker Snow collaborated on one of the great documents of bridge building history when they co-authored the paper "A History of the Development of Wooden Bridges," which was published in the *Proceedings* of the American Society of Civil Engineers in November 1932 when both authors were in their mid-80s. This paper is so highly valued as a pioneering study that it was reprinted by the American Society of Civil Engineers in their publication *American Wooden Bridges* in 1976, and in several reprints since 1976.[13]

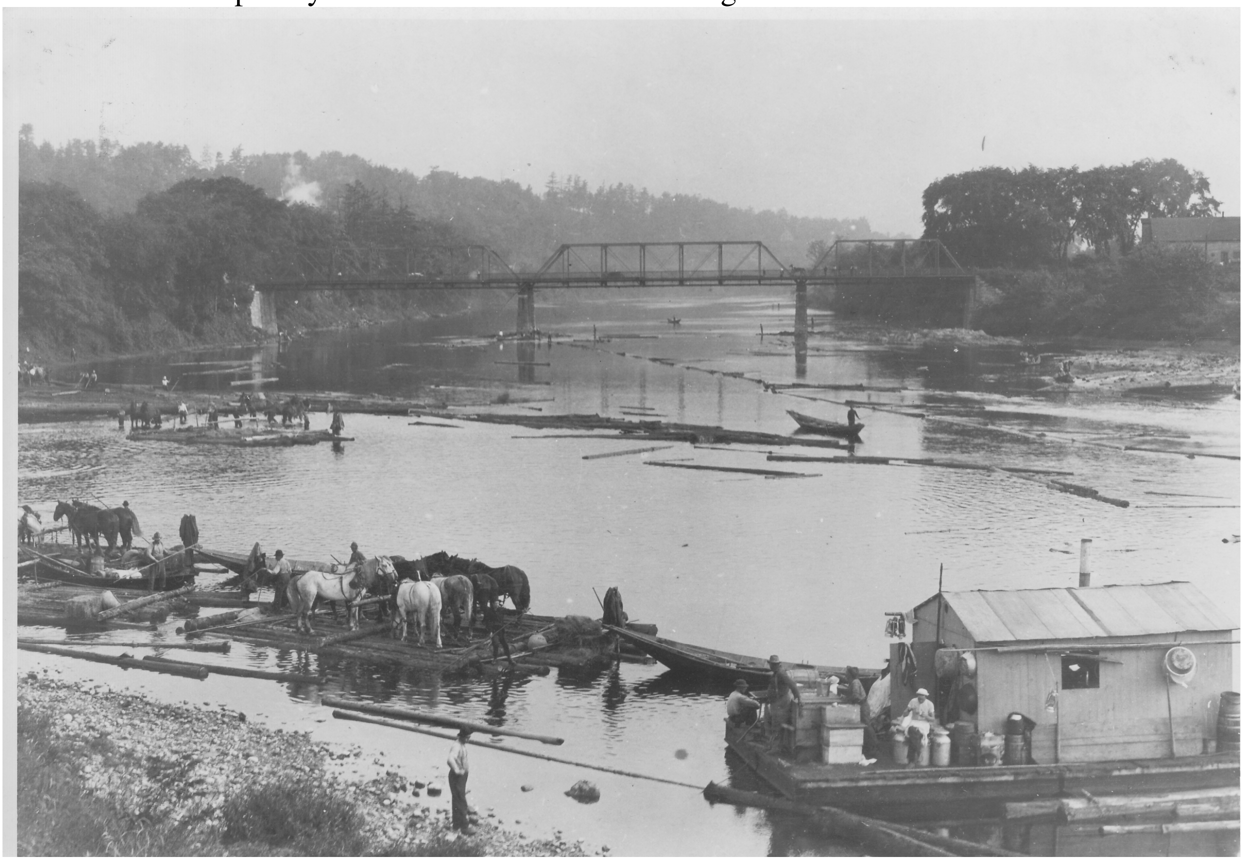
---

[11] *Report of the Bridge Commissioners of the State of New Hampshire to the Legislature, Dec. 31, 1906* (Manchester, N.H.: John B. Clarke Company, 1906), pp. 14-15.

[12] The following information about construction of the Berlin bridge is taken from the 1896 and 1897 published town reports of Lebanon, New Hampshire.

[13] The following facts regarding Fletcher may be found in American Society of Civil Engineers, Committee on History and Heritage of American Civil Engineering, *American Wooden Bridges* (New York: American Society of Civil Engineers, 1976): Robert Fletcher, educator, civil engineer. Born New York City, August 23, 1847, son of Edward H. and Mary A. (Hill) Fletcher (both from Cavendish, Vermont). Educated in public schools, the College of the City of New York (three years); U. S. Military Academy at West Point, 1868. Second Lieutenant, U. S. Artillery, serving at Brownsville, Texas and Fort Trumbull, New London, Connecticut. Instructor in Mathematics, U. S. Military Academy, 1869-70. Resigned to become senior professor and director of the Thayer School of Civil

Given Fletcher's prominence as head of one of the preeminent engineering schools in the United States, it may be conjectured that Fletcher actually designed the third Lyman's Bridge and that the Berlin Iron Bridge Company acted as fabricator and contractor rather than performing its traditional role of purveyor of a structure of its own design.[14]



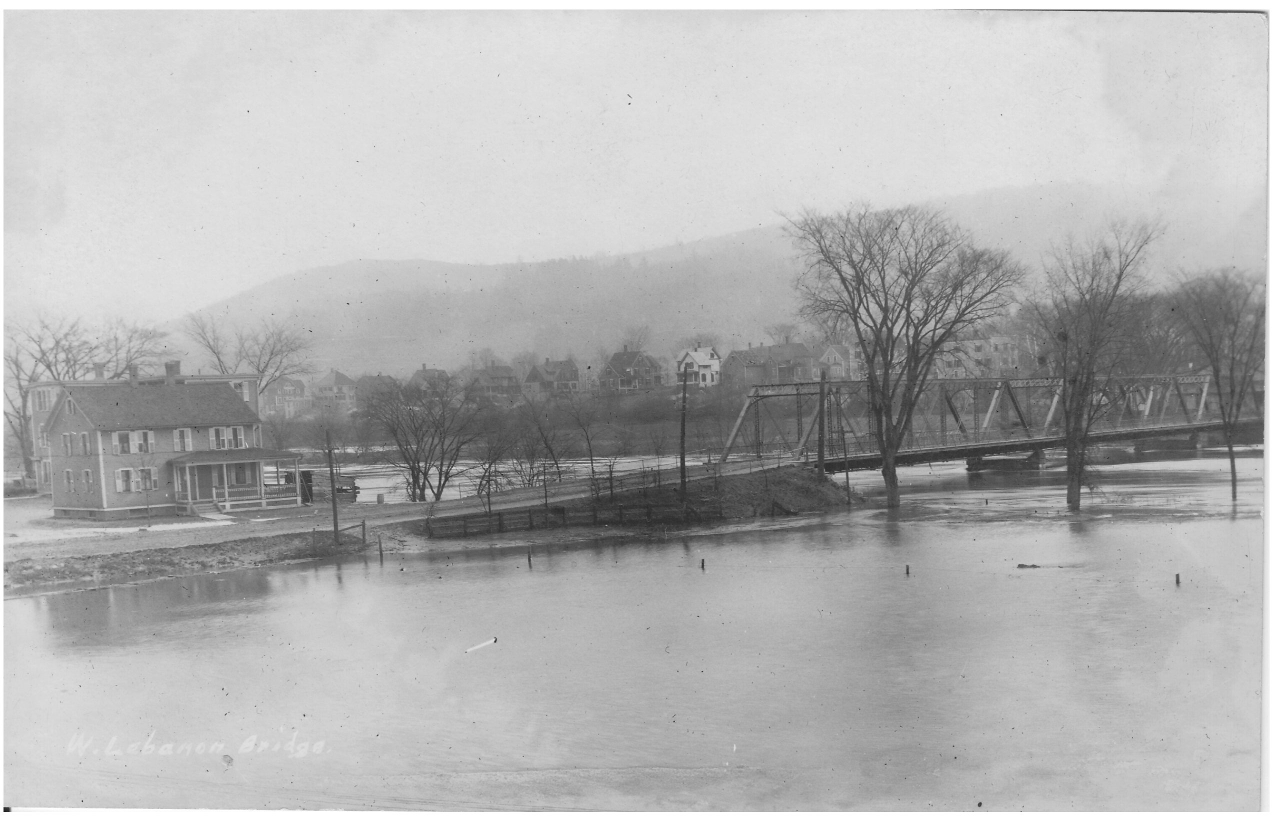
Third Lyman's Bridge during a log drive, circa 1900.
Courtesy of the Hartford, Vermont, Historical Society

Engineering at Dartmouth College in 1871, serving in that capacity for 47 years, retiring in 1918. Consulting engineer on water works and sanitation; engineer in charge of construction of Hanover Water Works, Enfield, N. H., 1893; reservoir for the water works of Hartford, Vermont. Consulting engineer for steel bridges of four [sic] spans each across the Connecticut River at West Lebanon, N. H., and across the White River at Hartford, Vermont. Conducted half of the New Hampshire-Vermont Boundary Survey, 1917. Contributor to technical papers and New Hampshire Bulletins on sanitation and engineering construction. Baptist. Republican. School trustee 17 years; member of the New Hampshire State Board of Health since 1895 (president since 1913); president and engineer, Hanover Water Works Company. Member, American Society of Civil Engineers since 1875. Member and past president of the Society for Promotion of Engineering Education. Honorary A. M., Dartmouth, 1871, Ph.D. 1881. Married Ellen M. Huntington, July 2, 1872; children: Mary A. Fletcher, Robert H. Fletcher (died 1919). Resided in Hanover, N. H. Died January 7, 1936. The Thayer School at Dartmouth annually confers a "Robert Fletcher Award" in honor of its first dean.

[14] A biographical sketch of Fletcher states that he "designed and supervised the construction of steel bridges across the Connecticut and White Rivers," though it provides no more specific information about these bridges. See William Phelps Kimball, *The First Hundreed Years of the Thayer School of Engineering at Dartmouth College* (Hanover, N. H.: University Press of New England, 1971), p. 40. For a thorough summary of the history and practices of the Berlin Iron Bridge Company, see Victor Darnell, "Lenticular Bridges from East Berlin, Connecticut," *IA: The Journal of the Society for Industrial Archeology* 5,1 (1979): 19-32.

Thus far, not much is known about the 1897 bridge. Given the practice of the time, the bridge was probably pin-connected rather than riveted at the panel points. The photograph reproduced above shows no obvious gusset plates at the panel points as would probably be visible in a riveted bridge. The new structure was probably fabricated from steel rather than from wrought iron; the 1906 report of the Bridge Commissioners describes the structure as "a new steel bridge . . . 427 feet long."[15] By the mid-1890s, the Bessemer process for making steel had been introduced into the United States from England and adapted to American ores. This innovation was combined with improvements in the open hearth method, an alternative steel-making technology that was better adapted to ores having the phosphorus content commonly found in North America. Together, these processes brought the cost of "mild" or low-carbon steel as low as that of wrought iron. Once its price was lowered, steel immediately supplanted all other materials for most new bridges. Steel's superior strength and homogeneity opened the possibility of bridges of greater span and complexity, including lift and draw bridges with movable spans.

The following photograph, taken during the flood of 1927, almost certainly reveals eye-bars and pinned joints at the bottom chords.



Post card view of the Third Lyman's Bridge during the flood of November 3-4, 1927.
Courtesy of the Hartford, Vermont, Historical Society

[15] *Report of the Bridge Commissioners of the State of New Hampshire to the Legislature, Dec. 31, 1906*, pp. 14-15. This length exceeds the combined length of the three trusses as reported by the Berlin Iron Bridge Company by 62 feet, and may include the raised causeway on the New Hampshire side.

At about this time, American engineers began increasingly to employ riveted rather than pinned joints. Pinned joints offer the advantage of accurate structural analysis by elementary methods and ensure simple axial stresses in each truss member, but a pinned truss lacks rigidity under moving loads. A pinned truss also lacks the ability to withstand the failure of a single joint or member. Because an end-pinned member can absorb no bending stresses, failure at a single point in the truss deranges the equilibrium of the entire structure. Such a failure usually results in the catastrophic collapse of the span.

Riveted joints, on the other hand, lock the ends of truss members together by rigid steel gusset plates. This rigidity gives a riveted truss greater stiffness under moving loads. At the same time, a truss with rigidly-connected members develops secondary stresses in its members. Because the ends of the truss members cannot rotate under varying loads, these members assume some bending stresses as well as axial stresses. In trusses of any complexity, these secondary stresses must be calculated and accommodated in the design of the members and the joints. While these added calculations can make the design of a riveted bridge more complicated than that of a pin-connected span, the ability of riveted truss members to absorb bending stresses reduces the likelihood of catastrophic failure of a bridge upon failure of a single joint or truss member.

Although European engineers were building long-span riveted bridges during the 1880s, American engineers did not generally adopt riveted trusses until the end of the century. In part, this was because bridge construction required that much riveting be done in the field as the span was erected. Field riveting requires heating a headed iron or steel plug to white heat in a portable forge, throwing the plug to a pair of riveters working on the structure, inserting the hot plug through pre-punched holes in the structure, and hammering the unshaped end of the plug to form a head like that already formed on the other end. In order to cause both heads of the rivet to clasp the bridge members tightly, one man had to press the headed end of the plug against a member as the other riveter formed the second head.

Until the 1890s, the heading of the unshaped end of the plug had to be done by blows from a sledgehammer on a swage in the time-honored tradition of the blacksmith. Field riveting therefore called for speed, strength, dexterity, and indifference to heights or other adverse conditions encountered in bridge work. Because these conditions could vary widely, field riveting often produced inconsistent results that were of concern to the engineer.

By 1900, development of the pneumatic hammer and portable, gasoline-powered air compressors inspired the rapid adoption of pneumatic field riveting. With such equipment, a hot rivet could be fitted tightly in its hole and given a perfectly-finished round head in mere seconds. Tests showed that such rivets had a high degree of uniformity and a reliable test-strength that made the capacity of riveted connections perfectly predictable by the designer.

The development of pneumatic riveting coincided with the American acceptance of riveted rather than pin-connected bridge trusses for most purposes. By the turn of the century, the riveted steel bridge had replaced the pin-connected wrought iron span in the United States. Boston and Maine Railroad engineer Jonathan Parker Snow, a former student of Robert Fletcher's and the co-author with Fletcher of an important paper on the history of wooden bridges, was one of the most persuasive American proponents of riveted steel bridges.

Since the 1897 bridge was built under the supervision of an engineer of national prominence at a time of transition from pinned connections to riveted connections, further research on this span should produce valuable documentation of the history of bridge engineering in New Hampshire and Vermont.

Description and significance of the current bridge: The West Lebanon-Harford Bridge (Bridge 058/127) on Route 4 between West Lebanon, New Hampshire and White River Junction in Hartford, Vermont, is a combination truss span. Its two high Pratt truss spans and its low Warren truss span offer representative examples of the types of truss bridges that were built after changes in steel rolling technology in the early twentieth century made possible the introduction of beams with new sectional properties that rendered truss bridge construction faster and cheaper. Because this new technology entered the field of truss bridge construction at precisely the time when northern New England was devastated by two major floods in 1927 and 1936, this region of the country became a proving ground for the new fabricating technology. The flood replacement bridges of northern New England provide examples of the final refinement of the design and fabrication of short-span high and low truss bridges in the United States. Few truss bridges were built in the region after World War II; in New Hampshire, only the two-span Lancaster-Lunenburg Bridge over the Connecticut River (1950) stands as a post-war truss highway bridge.

Truss bridges of the late 1920s and 1930s made use of new steel rolling technology that introduced wide-flange steel sections to the marketplace. These sections represented the first innovations since the American Standard rolled sections were adopted in 1896 by the Association of Steel Manufacturers. These new sections had sectional properties that permitted them to be utilized without modification as web members in bridge trusses, obviating the costly fabrication of built-up members created by riveting channels, angles, and plates into structural members. In New Hampshire and Vermont, flood replacement bridges represent the full maturation of the metal truss bridge and therefore have high engineering significance.

The Lebanon-Hartford Bridge utilizes built-up sections only in the heaviest and the lightest components of the trusses. The slanted end posts of the two high trusses and of the low truss are all fabricated from steel channels placed back-to-back and attached by top cover plates and bottom lacing. The portal bracing and the diagonals of the upper lateral bracing of the high trusses is composed of steel angles connected by lacing. The struts that run across the bridge at each upper panel point are fabricated from angles and solid plates.

Most of the other truss web members of both the high and low spans, however, are composed of wide-flange sections, with their wide flanges riveted to the gusset plates at each panel point essentially as they were delivered from the mill. All of the wide-flange members are 10" in height. They vary in weight-per-foot according to the stresses that they carry. In the two high trusses, they range from 33 to 54 pounds per foot. Similarly, most of the web members of the low Warren truss are all 10” wide-flange sections ranging in weight from 33 to 49 pounds per foot.

In both the high and low trusses, the floor beams are 33” wide-flange sections weighing 125 pounds per foot, and the stringers are 18” wide-flange sections weighting 47 pounds per foot.

Wide-flange steel beams had been a monopoly of Bethlehem Steel Company since the first years of the twentieth century, when that company developed the “universal” rolling mill largely to make these special shapes for steel-framed buildings. By January 1927, however, wide-flange sections were also being manufactured under license by United States Steel Corporation as Carnegie Beam Sections.[16] Thus, replacement bridges built after the flood of November, 1927, as well as those built after the flood of March, 1936 and the hurricane of 1938 could achieve economy and speed of fabrication by making consistent use of wide-flange sections as truss web members. A standard textbook of 1930 made note of the transition: “With the comparatively recent introduction by the steel companies of heavier and wider-flanged, rolled sections, another desirable type of compression member is available. . . . When such a section can be used, it offers many economies. No riveting is required except in its end connections, and the details of lacing bars and tie plates, essential parts of most compression members, are entirely absent.”[17] The cost of a wide-flange rolled beam of given structural properties was described as only about one third of the cost of a fabricated beam made of riveted angles, lacing, and cover plates.[18]

The Lebanon-Hartford Bridge is likewise significant as a custom-designed bridge that was fabricated to stand on an existing substructure, thereby speeding replacement by avoiding the need to clear the river of the 1897 piers and to build anew. Use of the existing abutments and piers resulted in three bridge spans of varying length, and called for an engineering decision to use high trusses for the two longer spans (148’-9” and 143’-6”), and a low or pony truss for the shortest span (88’-0”). Most flood replacement bridges were standardized designs and had identical pin-to-pin lengths when possible, even when the standardized truss length did not precisely match the old abutments; thus, the rapid but customized design of the Lebanon-Hartford Bridge was a resourceful response to an engineering challenge that had its roots in the history of the crossing and was confronted in the interest of speedy restoration of interstate traffic on this route.

---

[16] Carnegie Steel Company (a subsidiary of United States Steel Corporation), *Carnegie Beam Sections* (Pittsburgh, Pa.: Carnegie Steel Company, January 1, 1927). For a history of the development of the wide-flange steel beam, see Kenneth Warren, *Big Steel: The First Century of the United States Steel Corporation, 1901-2001* (Pittsburgh, Pa.: University of Pittsburgh Press, 2008), pp. 91-97.

[17] Leonard Church Urquhart and Charles Edward O’Rourke, *Design of Steel Structures* (New York: McGraw-Hill Book Company, 1930) pp. 226-227:

[18] J. M. Camp and C. B. Francis, *The Making, Shaping and Treating of Steel*. 5th ed. (Pittsburgh: Carnegie-Illinois Steel Corporation, 1940), pp. 773-774.